

NASA

April 8, 2004
3:30 p.m. CDT

Background noise, music on unmuted lines made transcription difficult.

Please remember to mute your phone (*6 on touch-phones) or we will ask the

Conferencing Center to mute you (which we did today!)

Highlights

1. Cassini Project Manager Bob Mitchell of JPL describes the Saturn Orbit Insertion geometry. Bio at <http://www.jpl.nasa.gov/releases/98/mitcherickson.html>
2. Interdisciplinary scientist Jeff Cuzzi of NASA/Ames gives overview of the orbital tour and various instruments, as well as the ring structure and ring hazards. Bio at http://heritage.stsci.edu/2001/15/bio/bio_cuzzi.html

Coordinator I would like to remind all participants that this conference is being recorded. If anyone has any objections, you may disconnect at this time. Ma'am, you may begin.

Anita Hi everyone, this is Anita Sohus at JPL. I want to welcome you to this kick-off telecon for the Cassini activities with the Museums, Science Centers, Planetaria, and now with the Amateur Observing Network, the Saturn Observation Campaign. Do we have Jane Jones [Coordinator for Saturn Observation Campaign <http://soc.jpl.nasa.gov/index.cfm>] on the line?

Jane Yes, you do.

Anita I'd like to introduce Bob Mitchell. He is the Project Manager here at JPL for Cassini and he has been with Cassini, I think, its whole life or close to it.

Bob Seems that way, now. Hasn't been, quite. Actually, I came on the project shortly after launch, so I've been involved now for about six years. Prior to that, I was the Galileo Project

Manager. We shared a common floor in a building here with the Cassini folks, so I feel like I've known the Cassini folks and been around them for even considerably longer than that; and in fact, I paid quite a bit of attention to their development phase because it had some implications to the Galileo project at the time.

Since launch, it's been a very interesting mission to be associated with. I can imagine the most likely impression people would have of a project that's out just cruising around the sun for six and a half years is that it's kind of a laid back activity, but in this case, at least, nothing could be further from the truth. At launch, we had a major development task ahead of us and that was by design. It was planned that way and it made a lot of sense.

Even in hindsight, I wouldn't recommend having done anything any differently because now, we've got a crew base that did a lot of this development activity that understands the system very well, the system meaning both the flying spacecraft, as well as the ground system, the tools, and the people. We've got a team in place now that is very well trained, very well motivated, very much feels a part of the team, and they're all up and excited and ready to go. It isn't going to be much longer now, as you obviously know.

Of the three charts that Anita sent out, we'll start with the first one that has the title of "Cassini-Huygens Saturn Approach Rev Zero." This is not the one with all the fancy color, but the one that's more just black and white.

Anita The one I labeled slide one, "Saturn Approach."

Bob On that, if you start off to the far right, at about two o'clock, that's where we'll pick up Cassini's trajectory as it's coming in toward Saturn. That far diamond out there that's labeled "TCM 20," that means trajectory correction maneuver. We talk about all these things as words in our vocabulary and don't have to spell it out very often.

TCM 20, this is a special activity for us because we're going to put the propulsion system in full-up operating mode, as we will have it for SOI [Saturn orbit insertion], but this will be the first time we have operated it in this mode since we did a large deep space maneuver back in December of 19...

(Background noise)

We have used the system several times in the meantime, but operated it in what is called blow-down mode, as opposed to ... supply open ... regulating pressure during the burn. This kind of a "wake it up, back it out, make sure it still knows how to work" kind of maneuver. It also is going to target us exactly to the conditions we need for the Phoebe flyby, which you see a little bit further to the left on June 11th.

(Background noise)

We fly by Phoebe at an altitude of 2,000 kilometers and we were fortunate to be able to line this up to work this way, because once we get in orbit about Saturn, we never again get as far out as Phoebe's orbit is. This is our only opportunity to see Phoebe. Phoebe is of particular interest because it's kind of an odd one as Saturn satellites go. It's in a retrograde orbit and a quite highly inclined orbit, and the scientists suspect that Phoebe probably didn't form with the Saturn system originally. It probably got captured from some place else.

(Background noise on unmuted line)

A little bit further to the left, you see TCM21. This is another trajectory maneuver that will correct for any of the [unclear] dispersions and some updated orbit determination knowledge after the Phoebe encounter. Then a few days later is TCM22. We don't expect to do TCM22. That is strictly a contingency, but we put it in the timeline. We have a window for it so it's a "just in case."

Then you see SOI minus eight days. This is where the sequence onboard the spacecraft will actually perform the orbit insertion burn first begins to clock down. Starting at that point, the spacecraft isn't doing anything other than ... on earth point and clocking down on that sequence.

As we go along, if anyone wants to ask questions, just speak up. Over here, see where we go down real close to Saturn, we'll talk about that in some detail on another chart, that's where orbit insertion occurs. Then at SOI plus two days, we have another maneuver to clean up any remaining residual dispersions from orbit insertion, and then back off to the right again is the periapsis [closest approach] raise maneuver of nearly 400 meters a second. We will be in full-up regulated mode in the propulsion system for that burn and then that will be the last such use of the propulsion system. From that point on, for the rest of the tour, it's just blow-down, using the helium pressure that's already in the propellant tanks.

That's the overview of what we've got coming up here in, now, a little less than three months. If you go to – is this page two?

Anita Yes, slide two, SOI Geometry. Bob, I have a question, but maybe you're going to cover this. How much propellant are you carrying and how much will be used for the SOI burn, a percentage or whatever.

Bob Gee, I don't know. At launch, we had a little over 3,000 kilograms of propellant.

Anita And that's hydrazine?

Bob No, that is not hydrazine. We had 132 kilograms of hydrazine, but that is a separate resource, separate propellant. We use the hydrazine and a different propulsion system to do very small Vernier-type corrections and to do attitude control. Of the 132 or so kilograms that we launched with, we've used about 14 or 15 so far in the mission; but the SOI burn, the periapsis raise burn, are done using what we call the bipropellant system.

For fuel, it uses MMH, or monomethylhydrazine, and for the oxidizer, it uses N_2O_4 , nitrogen tetroxide. The total of those two, fuel plus oxidizer, was a little over 3,000 kilograms at launch, and so far, we have used probably about a third of that. SOI, we use roughly another third and then the periapsis raise maneuver, plus navigation of the tour, plus propellant margin and for margin, we have something like 150 kilograms. That is roughly the other third. That's kind of how the propellant budget gets used.

To be pedantic about it, we always talk about propellant instead of fuel when we mean the entire resource because we have both fuel and oxidizer that we carry, separate items that together make up propellant.

(Cannot hear speaker)

Anita Part of the reason for the size of Cassini is to accommodate ...

(Static on the line)

Bob Yes, one of the reasons the spacecraft had to be this large is because to do all the maneuvers that we needed to do to fly this trajectory, it had to carry a lot of propellant, so the biggest, single thing making up the spacecraft is the propulsion system. When you look at pictures or look at our models ... that main central core in it, inside of that core is where the fuel and the oxidizer tanks are and so that's a big part of it. It makes an interesting design process because the bigger the spacecraft is, the bigger the propulsion system has to be. The bigger the propulsion system is, the bigger the spacecraft has to be.

Together, they gave us a spacecraft that weighed a little over 5,700 kilograms at launch and the total stack is not quite seven meters high, and that's the two tanks together. I forget what the diameter of the tanks is, but I think each is more than a meter in diameter, so that was a lot of what pushed the stack height up to almost seven meters.

SOI Geometry: if you look at this, the one that shows Saturn, kind of yellow in the middle, the spacecraft comes up on that orbit path, starting over on the left and you're looking edge-in on the rings, coming from behind the page out toward us and then goes back off the other side. You can see where we come through the ring plane. We're well out away from Saturn. ... entirely out of the part of the ring planes where there is actual ring material there, and then you see where

the head part of the line starts. That's where the burn starts and the burn lasts for about 98 minutes.

Periapsis in this plot is just about right in the middle of the arc that covers Saturn, maybe a little to the right of that; so it's near the end of the burn, but not quite, and then the burn ends where you see that boundary between a red line and a yellow line. The yellow line is where we make a quick turn to Earth after the burn is complete. The reason for that is kind of complicated and I won't go into it now, other than to say that it relates to the autonomous fault protection strategy that's built into the onboard software.

At the end of that yellow heavy segment, which lasts for about ten minutes, we turn the spacecraft over to the scientists and they turn and they're going to, mostly at least, image the rings that are at that point, quite close below us. Then, as we move to the right, we'll continue to image the rings as we move both in azimuth and in radius out over the ring plane, and then go back through the plane at just about exactly the same radius from Saturn, as we were when we came up through it.

You see those two arcs there, kind of one on top of the other; one is blue and one is yellow. Those are where the Earth occultation and solar occultation regions occur. This is where Saturn occults the spacecraft as seen from Earth and from the Sun. This doesn't affect anything, as far as the trajectory is concerned, or as far as the science activities are concerned. If we had been trying to track the spacecraft through this period, we couldn't have because Saturn would have come in the way, but we're not doing that and the spacecraft is off on what it was designed and sent there to do.

We go back down through the descending crossing and after that, we gather a little more science data. We're going to look back up at the rings from below it and then starting not too long after that, we begin to playback the data that has been acquired at that time.

Let's move onto the next one, which I suppose is figure three.

Anita Yes, slide three, SOI Geometry2.

Bob This one shows the same thing as the previous one did, except now we are up above Saturn looking down on the plane of the rings, as opposed to being down almost in the plane of the rings, looking edge-on. Starting up at the top is where we first come into view of this figure and you see the little green circle where we come through the plane of the rings ... inside of the D Ring and outside of the F Ring, so there isn't supposed to be any material in there that would be a hazard to us. I'm sure Jeff will tell you more about that in a little bit.

Then you see the same red arc burn, the same yellow arc for the Earth call home. The burn start time here shows as 01:12 GMT and that turns out in Pacific Daylight Time, local here to be

about, in addition to converting from GMT to Pacific Daylight Time, by the time you add to that a one-way light time, which is about an hour and 24 minutes, that translates into a little after 7:30 p.m. on a Wednesday night here in Pasadena.

Then a burn, lasting almost 100 minutes. The end of burn signal will be seen here on the ground at around 9:15 or thereabouts, Pasadena time. Then again, you see the same two occultations, although they aren't particularly significant for our purposes, and then continue on down.

Between these two slides, the intent is to give you a physical feel for what this thing looks like and what it's going to be doing. The total time getting through from ascending crossing to descending crossing is something like five and a half hours. The burn takes up about 100 minutes of that. The science data acquisition period, after the ... and before the descending ring plane crossing, takes about an hour and a quarter, and all these pieces together add up to about the five and a half hour amount.

What else should I tell you about this?

Anita You'll be out of radio communication for how long?

(Background conversation on an unmuted line)

Jane This is Jane over in the Cassini Outreach department. This last slide that Bob is talking about is on our Web site for those of you who maybe didn't get the slide. It's in the Cassini at Saturn section of the Web page of the Cassini-Huygens Web page, and it's under Saturn Arrival. A lot of what he just talked about is shown right on the Web page on this page.
<http://saturn.jpl.nasa.gov/operations/saturn-arrival.cfm>

Bob Anita asked about when we are going to be in radio contact with the spacecraft. If we start up off the top of the page, back before it shows here, we're sitting pointed at Earth. In fact, we will have been sitting there pointed at Earth and doing nothing for the previous eight days, communicating over the high-gain antenna. We'll have complete visibility into the spacecraft at that point.

About an hour before we go through the ring plane crossing, the switch from the high-gain antenna to the low-gain antenna, and we're going to turn the spacecraft to point the high-gain antenna in the direction that particles will be approaching the spacecraft going through the ring plane crossing, if in fact, there are any there. We think there aren't, but just as a safety precaution, we're going to point the high-gain antenna as a shield for the rest of the spacecraft, so there will be no com in that attitude.

Starting shortly after we've come through the ring plane crossing, we will turn the spacecraft to the attitude it needs to be in to do the burn; and in this attitude, we can see a radio signal coming

from the low-gain antenna. We couldn't get anything from the high-gain, so that's why we swapped to the low-gain; and even at that, we can't get any telemetry because there just isn't enough signal strength to do that, but we can see the carrier signal.

We'll start tracking the carrier signal as soon as it comes into view, which will be just a few minutes prior to start of the burn. Then, we'll track the burn for a while. We'll see the start and we'll track it for a while, but in this figure as you're looking down on it, Earth and the Sun are below the plane of the rings off at an angle in the same direction as you can see where the Sun is from the part of Saturn that is illuminated and the part that is not.

(Background noise)

With Earth in that direction, we will track until the signal first passes the A Ring, and when the signal is going through the A Ring – the spacecraft is not going through the A Ring – but the signal ... Earth will go through the A Ring and that will attenuate the signal to the point that we don't have any expectation of seeing it.

M Who is picking up the signal? Are you tracking with Goldstone?

Bob It's Canberra [Australia]. Goldstone will be up right at the very beginning of this activity, but it sets early on in it. The primary tracking station is going to be Canberra.

Then you see that gap in there between the A and the B Ring. We will see the signal as it goes through that gap that will last for a total of – I forget exactly – six or eight minutes, something like that and then as it goes through the B Ring, we expect to lose the signal again. But then as we get into the C and D Rings, those rings are thin enough, with sufficiently little material there, that we fully expect the signal to come right on through that. We'll see the signal from that point on up to the end of the burn.

(Background conversation on unmuted line)

... a while, be a few minutes in the middle, and we'll see the last part, including the end of the burn, to the point where we turn away and go back to ... After that, you see that short 10-minute yellow period when we're on Earth line, we'll have radio communications one way through that period. And then for the white part, we turn the spacecraft off and are collecting science data, so there's no radio com in that period, all the way down to the descending ring plane crossing.

(Unmuted line conversation continues)

There, we once again point the high-gain antenna and won't see the signal again until a half an hour or so, after we've gone through the ring plane crossing ... science data and then reoriented back to Earth. So that's what the radio com profile looks like over this five- or six-hour period.

Any other questions I could answer for you?

Dave This is Dave Cummings in Jacksonville, Florida. Are you going to do any measurements of any of these occultations?

Bob No. To do any kind of occultation measurements, you have to have a signal from the spacecraft to Earth and during these time periods, the spacecraft is going to be pointed off collecting remote sensing data, mostly of the rings. The short answer is no. Anything else?

Steve I have one, kind of an odd one. This is Steven Fentress in Rochester, New York. Is the deep space network antenna capable of resolving the side-to-side movement on the sky of the spacecraft as it goes behind the planet; or does the beam of the antenna basically pick up the whole planet and you're watching for other evidence of the spacecraft's motion in there, if you see what I mean?

Bob No, not entirely. Let me try to answer it and then, you tell me if I did or not. The only thing that we will track in this time period is the radial motion of the spacecraft. We'll see the range rate and we can track that clear up to the point that we turn the antenna too far away from Earth point. There's no side-to-side motion that we'll see. There's no interference with Saturn, other than, let me say, Saturn's gravity, of course, puts a side-to-side motion, or transverse motion, into the path of the spacecraft because of the acceleration it gives to the spacecraft and that in turn maps into the range, more accurately, I should say the range rate. We will see that and that would normally allow quite an accurate measure of Saturn's gravity, except that in this case, we're not tracking continuously ... information on that on this ... Does that answer it?

Steve I think, basically, yes. The Canberra antenna is not slewing to the left to follow this point as it disappears behind the disk of Saturn. The resolution isn't that high.

Bob It's not so much a matter of resolution, as it is that the motion of the spacecraft, the angular rate being this far away is essentially negligible, but the Canberra antenna is slewing to account for the rotation of Earth during this time period.

Steve Right. Thank you.

(Music on a line on hold)

Anita Jeff, do you want to talk about the rings? I was intrigued to hear that we're going to use the high-gain antenna as a shield.

Jeff Right. Let me say a couple words about the rings. I've been, myself, studying rings for pretty much my entire professional career. That goes back to about 1974; so I guess, Bob, you're just kind of a relative newbie to this kind of thing, huh?

Bob Yes, I am.

Jeff You've got to treat your elders with some respect, here.

Bob I'll keep that in mind, Jeff.

Jeff Anyway, so yes. I've been studying Saturn's rings from the ground and then I was on Voyager and then did a bunch of studies with Ames and with JPL back in the 70's. Planning for this thing has been going on really since the late 70's. It's been going on for a long time, and we're all very excited that, finally, after a lot of work by a lot of people, we are about ready to get there.

I would say, just to give you another perspective, Bob is the project manger. He's the head of the whole thing. I'm the guy who's tasked from the science side to worry mostly about the rings; that is I'm what they call an interdisciplinary scientist, so I'm really not on any of the instrument teams. And yet, also, I'm sort of on all of them. I try to make sure that everybody's science jives with everybody else's and keep an eye, to make sure that all the important problems are being addressed. We've probably got about 20 people on the project, who are fundamentally interested in rings, and that group, we get together and we talk about rings and we plan what parts of the tour we're going to do our stuff on and so on.

Anita, does everybody know the whole story? Bob didn't say much about the tour or anything. Is this all old news to everybody?

Anita No, this is the kick-off. Although most people on the line already know quite a little bit about Cassini, this is the kick-off meeting, so go for it.

Jeff Let me say just a couple more words about Cassini science, just right at the very, very top most level. After we get there and, basically, on the evening of June the 30th and we fire these rockets, and I'll say more about this SOI maneuver. And now basically, we're taking energy out of the spacecraft, so Saturn's gravity can grab onto it and hold it. Now we go into orbit around Saturn, a big long orbit, and that's the start of a four-year, what we call a tour of the Saturn system.

It will last four years and in those four years, we go around Saturn almost 80 times. We're planning 78; there are really 74 of these orbits, so Cassini becomes a little satellite of Saturn. It goes around these 80 times. The orbit of Cassini changes very dramatically, though. These

orbits are not all the same and we do that on purpose because we want to look at Saturn, and at the rings, and at all the various satellites, and at Titan, and at this whole extended Van Allen belt system of Saturn from a lot of directions because it looks different every way you look at it. We learn something new by going through these different geometries.

We change the orbit of the spacecraft and we do this by flying by this big moon, Titan, which is about as big as Jupiter's big satellites, Callisto, Ganymede, and so forth. It's almost as big as Mars. It has this very dense atmosphere of nitrogen and a haze of organic aerosols, and it's a fascinating object, all in its own right. In fact, it's one of the prime goals of Cassini to drop this probe that was designed and manufactured by the European Space Agency and that happens in December [24] '04.

We go into a couple of first orbits. They're like setup orbits for the probe and then, we drop the probe, fire it off. It goes down on a parachute and the heat shield enters the atmosphere and makes a lot of wonderful measurements of the composition and the density of the atmosphere and the clouds and even takes a few pictures on the way down. [January 15, 2005]

We go for the rest of the tour. Every time we fly by Titan, which we do 44 times out of the 74 orbits, Titan's gravity is strong enough to change the orbit of the spacecraft, make it more elongated or switch its direction around, and that's how we developed this tour petal. I'm sorry, I don't have any visuals, but I believe you can actually get a copy of that on the JPL Cassini Web site. <http://saturn.jpl.nasa.gov/operations/saturn-tour.cfm>

The tour design looks a little bit like a flower petal, with all these long orbits of the spacecraft going out in all these different directions and we flip it up over the top. We go up out of the equatorial plane and so on, which is all terrific stuff. This is all done by these very precisely planned swing-bys with Titan, so not only do we get this great science from Titan on these 44 flybys, but we also monkey around with the orbit in all these very profound ways.

Each one of these 74 orbits over these four years are all different and scientists have been discussing in a genteel sort of way with each other over the last, what, it's over two years now, I think, exactly how to best use this time. It's been a lot of planning that's happened and some of these orbits are better for certain things than others, so we've been doing all that. Anyway, that is more or less the overview of the tour.

Maybe, I should pause for a minute. If any of you have questions about the tour or anything I just said, maybe you might want to ask them now.

Edwin This is Edwin Montgomery from Pittsburgh, PA. Actually, I was an electronics design engineer on AACS for Cassini in the early 90's. Now, I'm over here. I have a question about the--how support changes because of some of the issues with the Doppler problem with the Huygens probe.

Jeff That's a very good question. Actually, Bob probably knows a lot more about that than I do. I'm happy to say a few words about it, Bob, but if you want to go ahead.

(Background noise on unmuted line)

Bob I'll start and then you can add on anything. It didn't change much. What it did was ... the way we solved the Doppler problem mostly was the orbiter path by Titan during the course of the relay length is very distant from Titan, distant to the tune of 60,000 kilometers at closest approach. So what that means is you're flying by, looking at the probe off to the side, as opposed to bearing in almost dead overhead of it. That reduced the closing speed from about 5.6 kilometers per second to something less than or equal to 3 kilometers per second during the course of the relay.

The way we did that was we made the Saturn orbit insertion burn a little longer, so that the post SOI period was 32 days less and then we added another orbit into the early part of the tour ... exactly make up for that. What we did was inserted one extra orbit, so instead of what initially was the first three, now occurs in what is now the first four, occurs in the same time period that initially was the first three. Everything from that period on in the tour is unchanged. ... but it might initially when we first started looking at it.

Eric Hello. This is Eric deJong Did you guys go over how many images per month can be expected in kind of like the duty cycle for this petal plot orbit configuration, when the images come down versus when it's quiet?

Jeff One way to think about this, this is actually something that is kind of interesting. We had to redesign Cassini because of cost limitations very, very soon after the mission was actually begun. What this meant was, we had to take the science instruments off of their own little separate platform and just bolt them onto the spacecraft. It's like not being able to chew gum and walk at the same time now. We can't both take observations from Saturn and send data back to the earth.

So what happens with Cassini is, we will point the spacecraft in a direction such that we're observing some satellite or we're observing the planet's aurora or we're observing the rings; and we'll store all this data onboard for typically 13 hours, 14 hours, 15 hours, something like that. Then for the other nine or so hours out of each 24-hour cycle, we will turn the spacecraft back, so the big antenna is pointing at one of these various ground systems, whichever one happens to be pointed in our direction at that time.

In that time we're taking data, we can store approximately 4,000 megabits or so, of various kinds of science data before we have to turn and send it back down. If you like to think about images, and that's certainly not all we're doing because Cassini has 12 different science instruments or

so, all of which are taking really cool data and all of which I'll be happy to explain to you if you like. But if you want to think of that in terms of pictures, each picture takes something like, let's say four megabits. You could think of it as about the equivalent of 1,000 pictures a day, more or less, if you wanted to. You can see we're sending down over the course of the mission, quite a lot of data over those four years.

Edwin Thank you. That really helps put it in context.

Jeff Right. Maybe then I could just say a little bit about the instruments. I don't know how many of you are old enough to remember Voyager, but I was part of Voyager and Voyager provides a good context. <http://voyager.jpl.nasa.gov/> Voyager, which was so fantastic, we had two of them fly by Saturn. Each Voyager flyby, which was full of new discoveries and great data, is the equivalent of one of our orbits. You can think of these 74 orbits as more or less the equivalent of 74 Voyager flybys. It's going to be quite a lot of return.

Now the instruments that are going onboard are either brand new to Saturn, some of them just never have been to Saturn before; and the ones that have been to Saturn, like cameras, are much higher quality, more sensitive, more filters, and so on, than anything that's ever been to Saturn before. All this data that we're going to get is going to be a lot more diverse and of higher quality than anything that we've had before.

You all know about pictures. We take pictures. We can take pictures with 15 different combinations of filters or colors. The cameras work in visible wavelength range, so it's reflected light from the sun. One of the other instruments that works in reflected light from the sun is called the near infrared spectrometer, and it's working in visible light and also in the near infrared. This one has a much coarser spatial resolution than the camera, but it has a lot more information about these very subtle details about how the material in the rings and in the satellites absorbs light. That's how we're actually going to tell what all the stuff is made of. It's a very important instrument.

Then there's another instrument that's capable of looking in the ultraviolet and actually sampling a signal very, very fast, like milliseconds. With that one, we actually watch stars go behind the rings and the planet, and we can actually see structure on a scale of meters in the course of, say, the rings. It's one of the ones I'm very interested in.

Occultations – we call them occultations because actually, the planet is kind of moving in front of a star and so the starlight blinks on and off, as rings of different amounts of material move in front of the star. Because the star is effectively a point with no real size to it, we're sampling the amount of ring material on this very, very fine scale.

M Are we going to be looking at the spokes with this instrument?

Jeff Probably not with the – actually, let me not be so hasty. For those of you who don't know, spokes are these shadowy features that we saw with Voyager and have also been seen from Hubble, by the way. Mostly, we'll be looking for them with the other instruments, the cameras, the near infrared, which are sort of imaging instruments. We want to see when they come and go, but there is one experiment that I'm involved in myself.

One of the theories for the formation of the spokes is that they're formed when meteoroids, big meteoroids, maybe a meter or so in size, come crashing into the rings at a very high velocity. Tiny, micrometeoroids are always falling into the Earth and all the planets. The little ones are accompanied by big ones. There are just many fewer of them, but because the ring area is so huge, every now and then, one of these meter sized guys goes through; and if it hits the rings at 50 kilometers a second, that's an enormous amount of energy. We expect to see flashes of light coming from these impacts. Flashes of light have actually been seen from the Leonid meteor showers hitting the moon.

We're going to look with this very instrument that I just described. We're going to stare into the shadow of the planet on the ring and look for flashes of light associated with these impacts. This is a very speculative and risky kind of an experiment because it's never been done before. We know that impacts make light, but we don't know the fraction of that light that comes out in the ultraviolet; and this particular instrument is only sensitive in the ultraviolet, so we're doing some modeling at the same time.

The idea here is if we can actually see evidence of these very impacts and then maybe with the cameras, take a picture an hour or two later that actually shows a spoke in the place that would correspond to where that impact happened, then we would be more likely to understand these spokes. That's a fun thing, but again, this is one of those things that you never quite know exactly how it's going to turn out.

That's three of the various cameras, you might say. The fourth of the cameras is a thermal infrared instrument, which is this big heat telescope. It's almost as big as an oil drum – not quite that big – but it's big as a big old canister. It's maybe a foot and a half across and it's sensing heat energy that's emitted by the rings and the planets in the infrared. They'll be using that one to take the temperature of Titan and its atmosphere and measure the structure of Saturn's atmosphere. We'll be measuring the rings and all the icy satellites looking for hot spots, maybe warm pools of who knows what all on some of these icy satellites, from their thermal signatures and this kind of thing.

Those are the four, what we would call the remote sensing instruments. Then, of course, we use the radio antenna itself to do several things. It has a radar on it that we're going to use when we go by Titan to actually map. It's a cloud penetrating radar, if you like, and it does this mapping of the surface of Titan in these swathes, like the Magellan radar mission did on Venus. Some of

you probably remember that one and we expect we'll get data that's every bit as spectacular as Magellan, only over a very small fraction of Titan's surface.

Then also, with this same antenna, we have the radio science experiment, which does these occultations, but at radio wavelengths, so now we have three different radio wavelengths, all the way from 2 centimeters to 13 centimeters. Here's a case where we're beaming this signal. As Bob mentioned, if you form the signal into a nicely tuned enough tone, you can actually detect all kinds of aspects of the material that it's going through, from the Earth; so now we're beaming the spacecraft's signal down through the rings, through the planet's atmosphere, picking it up at Goldstone or wherever, analyzing the signal for, again, the structure of the rings, the structure of the atmosphere, and so on.

A combination of those various experiments, you might call them your remote sensing experiments, and somebody else will tell you about this on another telecon much better than I can. There are another five or six instruments, maybe eight, that detect the properties of the magnetosphere, the electrons and protons, and the radio signals that are propagating in all that very distant region. It's all doing these things all at once.

Jane For those people who are interested and haven't looked at the Cassini Web site yet, there's a section, again, if you go to the first page, to the home page, and look under spacecraft, there's a section of Cassini orbiter instruments and Huygens probe instruments. It has a little page for each instrument, including in many cases, the instrument teams Web page. For those of you who have been concentrating on Mars and want to dip your feet into the Saturn world, there's tons of great information on our Web site. <http://saturn.jpl.nasa.gov/>

Jeff Yes, by comparison to Mars, this one moon of Saturn [Titan] is about the size of Mars. The rings are really vast. From one edge of the rings to the other edge of the rings is something like two-thirds or three-quarters of the distance from the Earth to the Moon, so this is really a giant, giant system.

M Twice the size of Jupiter.

Jeff That's about right, just about exactly, twice the size of Jupiter, which itself is what, about a million times the volume of the Earth, something like that.

M I know that you can contain all the other planets in the Solar System within the sphere of Jupiter if it were empty.

Jeff Yes, so this is a very, very big system. Maybe, while you're thinking, I could tell you a little bit about rings. I guess that's why I'm here. Rings are one of the four or five main goals of Cassini. Other people can tell you about Titan, about Saturn itself, about the magnetosphere, and about the icy satellites.

The rings are fascinating, both because of their intrinsic beauty, I believe, and the grandeur and the fact that certainly after Voyager, even now more than 20 years after Voyager, we still don't understand 90% of the structure that we see in the rings, just don't understand it. They have been known for a long time to be made mostly of water ice, and the particles in the rings are each independent boulders of ice, ranging in size from tiny dust grains, up to maybe the size of a car or the size of a house, generally speaking.

One of the other appeals of studying rings is that because we have this population of all these countless objects, all ... in Saturn's gravity and responding to Saturn's gravity and to their own gravity, the gravity of their neighbors, and collisions between them and their neighbors, and remote gravitational small tweaks from the nearby moonlets, it's actually not a bad analogy for what our own Solar System would have been like before any of our planets formed. We call it a dynamical analog to the Solar System, which was at one time a disk of particles and gas, orbiting the Sun, colliding with each other, responding to each other's gravity, responding to gravitational tweaks from large things, like Jupiter forming and asteroids and whatnot.

We think that here we've got a system that's kind of fossilized, could not form into big objects because it's too close to Saturn. All of Saturn's rings, and in fact, now we know that all the gas giants have rings systems, these tend to be inside what's called the Roche Limit of the planet, which is sort of the zone, where tides from the planet just frustrate any growth of an object, due to its own self-gravity. Objects can't grow by their own self-gravity when they're this close. Tides are just too strong. Growth may be trying to occur, but it just gets thwarted and frustrated, so we're left with this sort of fossilized dynamical machinery that we can explore and learn about the processes that go on in these particle disks.

This has been very, very important. When you look at Saturn [through a small telescope], you see the main rings. The outermost ring is the A Ring. Then you have this gap called the Cassini Division and then the bright ring in the middle is called the B Ring. That one is almost completely opaque in some places. We've never seen through it, and then the third ring that's closest to the planet is called the C Ring. It's very easy to see through that one.

In the outer ring, or the A Ring, there's a gap called the Encke Gap, which is a couple hundred kilometers across. We actually discovered there's a little moon in there, which is interesting and peculiar. How did it get there, etc.? But the fact is this moon is causing this gap and by understanding the physics of how this moon causes this gap, it is the identical physics of how Jupiter probably caused a gap in the solar nebula at the time Jupiter was forming.

So lots of people who study Saturn's rings go on to study planetary formation in our own planetary system and in all these other planetary systems we're discovering now. Those are the two reasons to be interested in rings, one, for their own fundamental beauty and mystery, and second, for the application in the broader context.

We have these main rings, and then there's a set of what we call the diffuse rings that are almost transparent, very difficult to see. We'll probably be going very near some of these as we head in toward the planet, as Bob mentioned; and this is where some of these ring hazard studies needed to be done that I can talk about. These things are called the F Ring, the G Ring, and the E Ring. There's something called the D Ring that's actually closer to the planet than the C Ring, and so on, so all this alphabet soup. [the rings were named in the order they were discovered]

Basically, there's a lot of material all around the planet, and a lot of these rings have the property of being time variable to some degree, little pieces and scraps and things come and go. We're interested in looking for time variation there, as well.

A lot of these rings are associated with probably asteroidal-sized things that are just too small for us to pick up directly, but they are constantly being bombarded by meteoroids and this ... of ejecta becomes this diffuse ring, or maybe they are, some people have suggested, ejecta of some kind from the moon, Enceladus.

(Static on the line)

The E Ring, there's this big broad diffuse patch of stuff that's sort of in the orbit of Enceladus. It makes it very interesting because Enceladus is almost, not quite devoid of craters, but there are smooth places on Enceladus that look like flow structures. There's this interesting connection between ice lava, ice volcanoes, and the E Ring. That's maybe a subject for another day.

The other thing I just want to say about the rings, and I'll stop here for a moment, is the composition of the rings changes from place to place. They're not all the same color. They're not all the same brightness. Some ring particles are darker than others and some regions are different colors than others. This tells us that their composition varies from place to place, more of this, less of that, maybe more carbon here. We think the overall pinkish color is some kind of organic material. All this, we don't really know anything about and that's one thing we're going to learn on Cassini.

That's a little bit of a very high level overview of ring science, if anybody wants to ask any questions about that.

Dave This is Dave Adalian in Visalia, California. Have we figured out yet what that braiding was that showed up in the Voyager images, and will you be looking for it again this time?

Jeff Yes, the braiding was in this thing that we called the F Ring. It's not quite a diffuse ring, but it's a fairly narrow ephemeral structure right outside the edge of Saturn's A Ring. Now, not a lot of people actually know that inside this Encke Gap that I referred to, which is in the A Ring,

where this little moon is, inside that gap, there are also two other little stranded rings, or arcs of rings, that look very much like the F Ring. They have their kinks and braids, too.

What we believe is that these kinks and braids are actually caused by some little moonlet in the vicinity that we have never seen, approaches that ring, maybe moves even through it; and as it goes very close to the ring, it actually strongly perturbs the orbits of these particles. So right near where this close encounter happens, the orbits of the particles get a little bit more elliptical. They seem to get this little kink and braid. Basically, all these particles are all going around Saturn in elliptical orbits. All this really means is that the particular particles at that particular longitude are a little bit more elliptical than their neighbors, and this is just because of this perturbation that they had.

We expect to see a whole different set of clumps and braids and whatnot, with the F Ring, as we go by. In fact, on the JPL Cassini Web site, is an approach picture of Saturn, which does show even, what now, two or three weeks ago, actual clumps in the F Ring, going around. We're seeing them already, probably not quite well enough to track their orbits, but we do know these things, they come and go. The clumps and braids that we saw at Voyager 1 were not there at Voyager 2 and that was only nine months later.

Yes, we expect to see a lot more of this. We're going to be looking, not only for the braids and clumps, but also for the little moonlets that cause the braids and clumps.

(Background conversation on unmuted line)

David Are those the so-called shepherd moons that they were expecting to find with Voyager?

Jeff Those two moons that we found with Voyager that were called the shepherd moons, at that time, we thought that they confined the F Ring into its narrow configuration. I think, since that time, although I don't know if this is unanimous, but it's certainly my belief, that those little moons don't really confine the F Ring.

The reason is they interact with each other and their dynamical interactions are more likely to be chaotic than regular. You probably know what chaos is and in fact, these two little moons, just in the last year or two years or so, discovered using some Hubble observations by Dick French at Wellesley and other collaborators, realized that the orbits of these little moons have actually changed, and they've changed significantly since Voyager [1980 and 81]. We think that their orbits are actually slightly chaotic themselves because of their mutual interactions.

My personal belief is that all that territory in between them is also chaotic, so I wouldn't be a bit surprised to find tribes of little moons in there, all of which that are on these slightly chaotic orbits. They're probably the ones that may be interacting. Maybe they collide with each other

every now and then. Maybe we'll get lucky during Voyager, and we'll get to see a whole new F Ring formed. That would be really cool.

David That would be something.

Jeff Yes. That's the story with the F Ring. Apparently, it's still there, more or less in the same place, and still behaving more or less the same. We'll know a lot more as we get closer. With these cameras being so much more sensitive, we should be able to see little moonlets down into the sub-kilometer size range.

I'm expecting over the tour, so not only in the F Ring, but also in all these other gaps in the rings. The main rings have about a dozen gaps, including the one, the Encke Gap, where we also see these kinky braided rings, where we will also be looking for other moonlets. There are all these other empty gaps, too, that we're going to be looking at.

Anita Can I break in for a minute, while Jeff is catching his breath? Please remember to mute. We're getting a lot of static on the line and we're getting a lot of outside conversations that are distracting.

W There might be some new people, Anita, and maybe everybody doesn't know how to mute.

Anita Press *6 if you don't have a Mute button.

Jeff Somebody said they had another question?

Steve Yes, I've got one. This is Steve in Rochester, New York. Thinking about the mechanism performing rings, this is sort of a basic, nine-year old's kind of question, how come Saturn's rings are by far the most prominent of all the four giant planets?

Jeff Yes, that's really a good one. We ask ourselves that question. It used to be – 20 years ago – it was why is Saturn the only planet to have rings, and now, of course, we know that Jupiter, Uranus, and Neptune also have ring systems. Those three are actually quite similar to each other. They have these ... narrow rings and embedded moonlets and they're all fairly dark material, but as you know, Saturn's rings are broad. They're quite massive. The thing that is sometimes surprising to people, the fact that they are so bright and white as they are, 90% water ice, or so, is actually a bit of a puzzle because of all of this meteoroid material falling on them.

Meteoroid material is primitive, let's say, cometary kind of stuff and it's pretty dark. If you were to sweep up anything like your own mass in that dark material, the rings could never be as bright as they are today. One of the questions is, first of all, how did the rings form and when did the rings form? Did they form at the same time Saturn's formed or not? This is not at all known.

It's thought from a couple of arguments that Saturn's rings may be only like one-tenth the age as old as the Solar System. It might have formed geologically very recently, maybe in the age of fish or something like, geologically.

Then you ask, how did that happen? There are two generic kinds of suggestions. One is that they were formed from an intrinsic parent and the other from an extrinsic parent. The intrinsic parent would be, let's say, Saturn had a satellite, let's say the size of Mimas, which is the inner most classical bright icy satellite of Saturn. It's the one that looks like the "Death Star" with that big crater.

Let's say, it was just orbiting Saturn and it got hit by some comet, or projectile, or something from a heliocentric body, some asteroid, whatever you want to call it, big enough and hard enough to actually destroy the thing and just rubblize it. Then the rings would be the rubble of a destroyed Saturn satellite. That's the intrinsic hypothesis.

The other one, the extrinsic process is it's the interloper itself that got torn apart by Saturn's gravity, like Comet Shoemaker-Levy got torn apart by Jupiter in 1996, I guess it was. Here you brought in something that was maybe like this new thing people have discovered called Sedna, this Outer Solar System icy red object that just came too close. We all believe that Neptune's satellite, Triton, is a captured object and Triton is quite large and it's quite bright.

There's precedent for big, bright things floating around in the Outer Solar System and encountering planets and having their orbits severely changed. Okay, Triton just got captured. Maybe something went by Saturn, didn't get captured, but maybe got torn apart by Saturn's tides and left some material behind. That's hypothesis number two.

One of the reasons that it's so important to measure the composition of Saturn's rings and understand how they might have changed over time is because now, here's something we can compare between Saturn's rings and other things we can observe, like Saturn's other satellites or Sedna and the other icy Solar System objects we can observe with big telescopes from the ground. There's where we might be able to make this connection.

I should tell you that it remains a bit of a puzzle, because either one of these eventualities is believed to be low probability. It's a low probability event that anything big enough to destroy a Mimas size satellite could actually happen since the age of fishes, and the same thing with one of these close encounters. We ran our best numbers. We got these low probabilities. It doesn't mean impossible and since there are four outer planets and we only have one Saturn's rings, you might say, "If the probability weren't low, then all of them would have rings like Saturn's," and in fact, they don't. That's the situation.

Steve I'll follow up with that. Would the same mechanism ever work or have worked with smaller planets, like terrestrial planets? Would they have ever have rings?

Jeff People have thought about that, on and off, over the millennia and I think the answer probably has to be yes. In fact, if you go back to the formation of the Earth and the Moon, the leading idea there is the giant impact that actually formed the moon. On the way to becoming the moon, what we actually had was a ring around the Earth, of debris and rubble; and that debris and rubble was far enough away in this case, or enough of it was far enough away from the Earth that it was outside the Roche Limit and it could actually coalesce and form a moon, so yes.

In the case of – how would this go – the probabilities of all these things are smaller, much smaller, for the Earth because it's smaller. It's like it's a smaller target. The likelihood of anything getting close enough to the Earth to either hit it or be torn apart by its tides is a lot smaller than it is for Jupiter or Saturn. This happens to Jupiter all the time. In fact, it's always tearing comets apart.

You can go and find dozens of these crater streaks on the surfaces of the icy satellites that are just obviously, here's another Comet Shoemaker-Levy just got torn apart, and on its way away from Jupiter, got whacked into a satellite. It has definitely happened many times to Jupiter. It has probably happened a number of times to Saturn, as well, but the Earth, I would say the chances, although possible in principle, chances are a little bit lower.

Chuck Question about size particle?

Jeff Sure.

Chuck This is Chuck Bueter in Indiana. It had been suggested that the antenna is going to be used as a sacrificial shield. What size particles is that going to be scooping up and protecting the spacecraft from?

Jeff That's a good one. That actually gets to this whole question of ring hazard. I don't quite know where to start this. The direct answer to your question is sort of in the millimeter size range. Let me just get that right off the bat right away. The antenna itself, as somebody was saying – I was just down at JPL yesterday or the day before – the antenna itself, because it's working at centimeter wavelengths, we can suffer little pits in it, a little crater, even a little hole. It's not going to degrade its performance as an antenna. Like the screen in your microwave oven has all these little holes that you can see through, but the radar waves can't get through, so same deal.

The risk of damage to the spacecraft is a combination of obviously, the larger the particle, the worse damage it does. Moving at these relative velocities of kilometers per second, a typical particle, it's like a little kinetic kill vehicle. A particle has more energy than an equivalent amount of mass of TNT, just because of the relative energies in motion, so even a small particle can do a lot of damage.

The bigger particles could obviously do more damage, but there are fewer of them. Typically, when we look at particles out there, we see these size distributions, where you have just a few big ones and you get increasingly numerous particles as you go to smaller and smaller sizes. It's a little bit of a trade-off.

I think we've decided, JPL has done analyses, a number of very careful analyses, of all the different components on the spacecraft that are the most vulnerable. Obviously, we don't want to point our telescopes into even micron-sized particles because you don't want to sandblast your optics, so we want to avoid that from a science standpoint.

From a safety of the spacecraft standpoint, the most vulnerable parts of the spacecraft are like the electronics and the various wires and harnesses. People have looked at all this very, very carefully, right down to the square centimeter, how many square centimeters and where are they on the spacecraft and how do we do all this? That's the idea is when we go through any area that has a chance of being dangerous; and we're going to know a lot more about this after we've been there a while and actually gone through some of these areas, we do turn the spacecraft, so that the antenna goes first, like a shield, and we take a few hits on the antenna to protect the more vulnerable areas. That's the way it's going to work.

When we actually did these studies, started right away when the project was formed. Actually, there was a study, I believe, even before the project was approved by Congress and the White House back in 1989. We did a study of where the ring material was dangerous, where we wouldn't want to go through the rings. Was it possible to find a place that was safe? Then we repeated that study in 1995 to 1996, with a whole group of people, a couple dozen people or so, ring scientists from all over the place. We got new Hubble observations. We got new ground-based observations from the big Keck telescope in Hawaii. We did analysis. We looked at the Van Allen Belt, the magnetosphere data that Voyager had acquired as it went through the Saturn system [1980 and '81]. Pioneer 11 had gone by earlier than that [1979].

Actually, one of these spacecraft actually went pretty much right through the diffuse G Ring and measured quite a few particles. There was this little hailstorm you could hear of hits on the spacecraft [from the Voyager plasma wave subsystem data]. Most of these are in the micron-size range and too small to really do any damage, but where there are small things, there are bigger things. We didn't want to be taking unnecessary chances with Cassini, that maybe Voyager 2 just got lucky. We're just not taking that kind of chance.

All these studies, we combined this data of different kinds, spacecraft data, ground based data, particle and fuel data, and tried to decide, where is the region to go to that is the least likely to contain harmful material and how much could be there. As a result of those studies, that's how we picked this crossing location that Bob mentioned. It's inside the G Ring and it's outside the F

Ring, and it's outside these other two satellites that we call the co-orbital satellites. It's in a region, where as far as we can tell, no matter has ever been detected.

It's possible to dream up a pathological situation, where an amount of material that we may not have detected yet, if it was all in the worst possible particle size, and if we got unlucky, could be hazardous. It just depends on do you believe in pathological situations. We're being as careful as we can, and we're actually trying to get a little data on the way in with Cassini, to be sure that things are still looking okay.

Edwin This is Edwin Montgomery, again, in Pittsburgh. When will you know that the orbit insertion has been successful?

Jeff Bob, you may want to take that one.

Bob We're tracking this Doppler signal from this one-way radio signal we'll have during the burn, and during the burn, the Doppler signal will be ramping down, as the burn slows the spacecraft and when the burn stops, that signal will level out. We will know in just about real time, one-way light time later, that it was at least very nearly successful or not. Now we won't know very accurately for a day or two. Near real time, we'll know very closely.

Edwin Was that similar to what was done, I guess, in Galileo when it did an orbit insertion for Jupiter?

Bob Yes, it will be exactly the same principle.

Jane It will be about 9:15.

Bob About 9:15, local, PDT here. Right.

Anita Other questions for Bob or Jeff?

Steve Yes, Steve again. Is Saturn orbit insertion the closest you will be to the rings?

Bob Yes, in terms of closeness to the main, dense part of the rings, the inner part of the rings, yes. It's the closest we ever get to both the rings and to the cloud tops of Saturn. At the point of closest approach to Saturn, we're about 20,000 kilometers above the atmosphere and 20,000 kilometers above the rings, and then in that next hour and a half, of course, we get back down to the ring plane.

Steve Here's another question, one of those nine year old type questions, and that is how close are we – and I'm doing a little rough figuring here – to ever seeing an individual ring particle?

Jeff That's one of those fun science things that Bob mentioned that we are going to try to do a little science, right after the end of the burn. While we're in this environment, we're actually sitting right up on top of the rings and as Bob said, by the time you add in the fact we're not looking directly down, it's maybe 30,000 or so kilometers, but it's six times closer than we ever get to the rings again.

We're doing two kinds of things in that, I don't know, it's about 40 minutes or so period. We're staring at the rings with all of our instruments; and even though the camera has the highest resolution, it's still the best time for any of the instruments just to get their highest resolution data on the rings. We're just scanning right out across the rings. All of the different instruments are taking their best data as fast as they can.

During the middle of that time, the camera's resolution, which is the best resolution anybody has, is good enough that we might be able to see individual large lumps of stuff. I'm not sure I would necessarily call them individual ring particles; but they may be these transient gravitational clumps of particles that we know or we believe from other observations and models are there. These things are probably just like strands or just little knots of particles and they might be tens of meters in one dimension by a couple hundred meters in the other dimension. We may actually get really, really lucky and see these structures. That would be absolutely terrific.

Anita Are you going to try to take an edge-on view of the rings as you go through?

Jeff Not on this particular time. We're just going too fast and we're too concerned with staying safe, but during the other parts of the tour, there are parts of the tour, where we actually stay in the equatorial plane for months at a time, so we'll be getting a lot of those during that time.

The other thing I should tell you about the science we'll be doing during this time period is we're actually going to do some direct sniffing of the atmosphere of the rings and the material that may be moving between the rings and the planet. This is something there just is simply no other way to do this, so there are lots of really cool scientific things that are going on in this very brief, very intense time period.

Anita Great. Other questions? Bob, we're not going to see pictures that first night, right? It will probably be at least the next morning.

Bob It will probably be the next morning. We first start receiving data on the ground at around midnight the 30th, but the first data to come down is engineering telemetry that will characterize what happened to the spacecraft during the burn. Then as we get through the data recorded on the recorders, the images start hitting the ground around 4:00 a.m. or 5:00 a.m. on July 1st. By the time we get them processed and in a condition that they can be shown and viewed, it will be midmorning or so, on the 1st.

Anita Other questions? We have the line for about another 15 minutes, if we need it.

Edwin This is Edwin again, in Pittsburgh. We'll be available, I guess, to receive real time feeds or maybe something on the Web site to watch or observe, like orbit insertion.

Anita NASA TV will be covering it.

Bob And on that, we're not sure yet exactly what we'll have, but I would expect at the very least, you will be able to see the Doppler profile as we track it through the burn and there undoubtedly will be shots of the mission support area, very much like you may have seen for MER.

Anita Yes, probably interspersed with some interviews of folks to explain what's going on and what we expect.

Dave This is Dave Adalian again; and I had a question about the end of the mission. I know there was a lot of controversy before Cassini was launched because of the 92 pounds of plutonium that is onboard as a fuel supply, or actually, electrical generation supply. What's going to happen to it at the end of the mission? Where does it go?

Bob Undetermined, so far. We are hopeful that after our four years of prime funded mission are up, that we'll still have a perfectly well operating spacecraft and funding from NASA to continue the mission. We might well do another two or four or six years, just as Galileo did.

We just recently have had a communication with the Planetary Protection Officer at NASA Headquarters on exactly this subject; and we have agreed in our Planetary Protection Plan that we're just now updating, that we're going to put a statement in there that says that for now, we're not going to address that question, but will recognize that at some point in the mission, while we still have control of the spacecraft, we will need to do that.

Part of the reason for postponing a decision at this point is that, we don't yet know what we're going to discover and what bodies might be particularly sensitive to this kind of thing or not. For example, on Galileo, at this point in Galileo's mission, probably nobody would have been particularly concerned about the spacecraft crashing into Europa; but as we got smarter and smarter, we decided that Europa was something that was very much worth protecting. We'll wait for those kinds of discoveries on this mission before making a decision on that.

Dave Have we planned out any options, just some contingencies, or are we just going to wait and see?

Bob Just wait and see, but the most natural orbits that this thing would be left in, if we chose to do nothing, would be orbits that would have pretty low probability of impacting anything for a very long time anyway. There are quite a few moons out there, but there is also an awful lot of space.

Dave More space than moons, that's for sure.

Bob Yes.

Lou Lou Mayo at NASA Goddard. I heard in a briefing a couple of days ago that with the new Moon/Mars Initiative, there a number of missions that are going to get just turned off, active missions. This particular comment was made about Sun/Earth Connection missions and that's where Voyager falls right now. The understanding is that there is a proposal to shut down Voyager in '06.

My question is – it's a little off the science end – but I would imagine that this might shed some doubt regarding an extended Cassini mission, which has been viewed as a very high priority for the planetary community. Any thoughts on that?

Bob I don't have anything definitive on that. I have not heard any discussions of this specifically directed to Cassini; but four years from now when we know better exactly what this Initiative is going to amount to, and when we will know exactly what Cassini has done, or not done, and how it continues to be functioning, I think all those things will weigh into a decision at that time; that we would really have little prospect of accurately making any predictions of today. In the meantime, it's something that I really haven't worried about. If we get four years of successful mission behind us, I'll consider this to have been a success and we'll worry about the next steps then.

Anita NASA really doesn't like to turn off a functioning mission if they can possibly help it, even though the funding is always difficult. Other questions?

We don't have the Cassini Muse page up. I will let you guys know when it is up. In the meantime, I will try to send you stuff through e-mail or put it on that Informal Ed Web site that I put in that last e-mail. I think Jane will forward that to the Amateur Network folks as well.

What we were thinking of doing is continuing the Mars telecons like this and alternating weeks with the Cassini topic, so we've been doing the Mars telecons at 11:00 Pacific on Tuesdays ... that will work for most people and we'll just alternate topics from Mars to Saturn and back every week, as Mars is getting a little more routine, if that's possible, and Saturn is ramping up. You will be getting a reminder e-mail on Mondays about the telecon and if we have a guest speaker, I'll announce that then, too.

If there are no other questions, I really thank Jeff and Bob for taking a chunk out of their day to kick-off this whole activity. We'll talk to you guys via e-mail probably very soon. Thank you.